

QUANTIFICATION OF IN-FLIGHT PHYSICAL CHANGES: ANTHROPOMETRY AND NEUTRAL BODY POSTURE

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ABSTRACT

Currently, NASA does not have sufficient in-flight anthropometric data gathered to assess the impact of physical body shape and size changes on suit sizing. For developing future planetary and reduced gravity suits, NASA needs to quantify the impacts of microgravity on anthropometry, body posture, and neutral body postures (NBP) to ensure optimal crew performance, fit, and comfort. To obtain these impacts, anthropometric data, circumference, length, height, breadth, and depth for body segments (i.e. chest, waist, bicep, thigh, calf) from astronauts for pre, in-, and postflight conditions needs to be collected. Once this data has been collected, a comparison between pre, in-, and postflight anthropometric values will be analyzed, yielding microgravity factors. The NBP will be used to determined body posture (joint angle) changes between subjects throughout the duration of a mission. Data collection, starting with Increments 37/38, is still in progress with the completion of 3 out of 12 subjects.

NASA suit engineers and NASA's Extravehicular Activity (EVA) Project Office have identified that suit fit in microgravity could become an issue. It has been noted that crewmembers often need to adjust their suit sizing once they are in orbit. This adjustment could be due to microgravity effects on anthropometry and postural changes, and is necessary to ensure optimal crew performance, fit, and comfort in space. To date, the only data collected to determine the effects of microgravity on physical human changes have been during Skylab, STS-57, and a recent HRP study on seated height changes due to spinal elongation (Spinal Elongation, Master Task List [MTL] #221). The Skylab and the STS-57 studies found that there is a distinct neutral body posture (NBP) based on photographs. The still photographs showed that there is a distinguishable posture with the arms raised and the shoulder abducted; and, in addition, the knees were flexed with noticeable hip flexion and the foot plantar flexed [1,2]. This is the one standard set of body joint angles for a NBP in microgravity. A recent simulated microgravity NBP study [3] has shown an individual variability and inconsistencies in defining NBP. This variation may be influenced by spinal growth, the type of suit fit, and other potential anthropometry factors such as spinal curvature, age, and gender. The variation aspect of this essential data is required for all kinds of space device designs (e.g. suits, habitat, mobility aids, etc.). The method proposed considers the dynamic nature of body movement and will use a measurement technique to continually monitor posture and develop a probability likelihood of the natural posture and how the NBP postures are affected by anthropometry.

Additionally, Skylab studies found that crewmembers experienced a stature growth of up to 3%. The data included 3 crewmembers that showed that there is a bi-phasic stature growth once the crew enters into weightlessness. However, the Spinal Elongation study identified that the crewmembers could experience about a 6% growth in seated height and a 3% stature growth, when exposed to microgravity. The results prove that not all anthropometric measurements have the same microgravity percent growth factor. For EVA and suit engineers to properly update the sizing protocol for microgravity, they need additional anthropometric data from space missions. Hence, this study is aimed to gather additional in-flight anthropometric measurements, such as length, depth, breadth, and circumference, to determine the changes to body shape and size due to microgravity effects. It is anticipated that by recording the potential changes to body shape and size, a better suit sizing protocol will be developed for ISS and other space missions. In essence, this study will help NASA quantify the impacts of microgravity on anthropometry to ensure optimal crew performance, fit, and comfort. This study will use simplistic data collection techniques, 3D laser scanning, digital still, and video data, and perform photogrammetric analyses to determine the changes that occur to the body shape, size, and NBP when exposed to a microgravity environment.

[1] Brown J. (1975). ASTP002: Skylab 4 and ASTP Crew Height. Retrieved December 28, 2007, from NASA Life Sciences Data Archive Web site: <http://lsda.jsc.nasa.gov>

[2] Brown J. (1977). Crew Height Measurement. In: Nicogossian, A. (Ed.), The Apollo-Soyuz Test Project Medical Report (p. 119-121). Washington, DC: National Aeronautics and Space Administration.

[3] Dirlich T. (2010). Experiments in simulated microgravity under water: preliminary findings on individual neutral postures, Applied Human Factors and Ergonomics Conference Book, CRC Press